# Section 1.0

# Introduction

Residential wood combustion (RWC) has been identified as a major source of particulate matter (PM) and polycyclic organic matter (POM) air emissions. During 1997, RWC contributed an estimated 12% of the sum of the total $PM_{10}$ emissions attributed to all fuel combustion, industrial process, and transportation sources combined (1). RWC was also identified as the largest single source of POM during 1990 (2). Approximately 72% of the cordwood burned annually in the United States in the category of residential wood combustion is in woodstoves (2). (The remaining 28% is mostly burned in fireplaces.) There were an estimated 9.3 million woodstoves in homes during the 1997-1998 heating season (3).

Due to the level of emissions attributed to woodstoves, standards of performance were promulgated for new residential wood heaters (4). All wood heaters sold after July 1, 1992, have to meet the most stringent Phase 2 particulate emission limits of the standards. These standards were 4.1 gram per hour for catalytic stoves and 7.5 grams per hour for non-catalytic stoves. The limits for catalytic stoves were set lower than non-catalytic stoves since the presumed deterioration of the catalyst over time was estimated to result in emissions from catalytic wood heaters over their useful lifetimes approximately equal to non-catalyic wood heaters.

Furthermore, there has been concern about the overall physical deterioration of wood stoves with use and the commensurate increase in air emissions. This concern has been confirmed in both laboratory (5,6) and in-home studies (7-9). Physical degradation coupled with higher PM emissions has been documented for some stoves. Not only are accurate airshed inventories of PM and POM fundamentally important for health and environmental assessments, state and local agencies in areas of $PM_{10}$ nonattainment have been directed to take performance degradation into consideration in their State Implementation Plans (SIPs) when calculating credits from replacing non-certified stoves with certified stoves (10). The replacement of non-certified stoves with Phase 2 certified stoves remains a viable option for reducing airshed pollutant levels and obtaining $PM_{10}$ SIP credits because, as of 1997, more than 80% of the woodstoves in use were still older non-certified units (11). In addition, because over 90% of the $PM_{10}$ emissions from residential wood combustion are also $PM_{2.5}$, emission credits may be very important for possible future $PM_{2.5}$ nonattainment areas.

The primary objective of the study was to select Phase 2 stoves that were installed in homes prior to the fall of 1992 in order to assess the level of long-term degradation and potential

increase in PM and POM air emissions of older Phase 2 certified stoves under actual in-home usage. Woodstoves in homes in both Portland, Oregon, and Klamath Falls, Oregon, were selected because Portland is in U.S. climate zone three and Klamath Falls is in U.S. climate zone two. The average heating degree day (HDD) value for Portland is 4109 and the average HDD for Klamath Falls is 6600. The intent behind the selection of stoves in the two climatologically dissimilar cities was to produce results more widely applicable to woodstove usage in the nation as a whole than if homes in a single city were selected. In addition, nine Phase 2 stoves installed in homes in Klamath Falls were previously studied during the 1989-1990 and 1991-1992 heating seasons (8,12,13). Therefore, a secondary objective of the study was to utilize as many of these homes as possible in the current study to help document phase 2 stove degradation and commensurate emission increase.

Sixteen homes were targeted for study during the 1998-1999 heating season. Two in the study group were homes in Klamath Falls that had phase 2 woodstoves that were part of the earlier studies. Emission samples were collected for three one-week periods from woodstoves in each home using the Automated Woodstove Emission Sampler (AWES) previously developed by OMNI Environmental Services, Inc., for similar studies. Samples collected with the AWES were analyzed for particulate matter and organic compounds. The specific organic compounds analyzed included the seven and sixteen POM compounds needed to calculate the 7-PAH and 16-PAH values, respectively, which are used as surrogate indicators for POM. The PM and POM surrogate emission factors (mass of pollutant emissions per unit mass of fuel) were compared against their emission factors tabulated in AP-42 for woodstoves (14). The PM emission rates (mass of pollutant emissions per time of stove operation) measured under actual in-home use for each woodstove model were compared against their certified emission values listed by the U.S. Environmental Protection Agency (15). The PM emissions from this study and from the previous studies were compared for the stoves in the Klamath Falls homes that were part of earlier studies. Cordwood tree species, cordwood moisture, the amount of cordwood burned, burn rates, ambient temperature during testing, a description of woodstove use in each home, chimney characteristics, and the condition of the stoves were also documented as part of the study. Photographs of each stove's installation and components that showed degradation have been included as Appendix A.